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Chromosome evolution in the genus *Acomys*: Chromosome banding analysis of *Acomys* cf. *dimidiatus* (Rodentia, Muridae)

V. T. Volobouev, M. Tranier & B. Dutrillaux

Abstract. Chromosome analysis (R- and C-bands) of *Acomys* cf. *dimidiatus*, from Saudi Arabia ($2n = 38$, N. F. = 70) and comparison of its banding patterns with those of *A. airensis*, from Niger, studied previously ($2n = 42$, N. F. = 68) revealed that in these species all chromosomal arms except three have similar banding patterns. At the same time there are no identical pairs of biarmed chromosomes among 16 of *A. cf. dimidiatus* and 13 pairs of *A. airensis* due to different combinations of fusions of acrocentric into metacentric chromosomes. This means that both lineages of *Acomys* were issued from a common ancestor which had a karyotype composed of acrocentrics only, and that their subsequent evolution was independent. The data predict the existence of other chromosome races and sibling species in the *cahirinus-dimidiatus* group and points out the importance of chromosome banding analyses especially among the forms with a high number of biarmed chromosomes.

Key words. Rodentia, Muridae, *Acomys*, chromosome evolution.

Introduction

Chromosome studies of the genus *Acomys* have revealed a fairly large variation of diploid numbers, from 36 to 66, with relatively low variation of the Nombre Fundamental (N. F.), from 66 to 76 (Table 1). This was previously interpreted as an indication of the predominance of the fusion-fission events in the chromosome evolution of *Acomys* species (Zahavi & Wahrman 1956; Matthey 1963; Wahrman & Goitein 1972). Moreover, these authors performed meiotic studies of hybrids obtained between Israel, Cyprus and Crete forms and assumed that metacentric chromosomes had been produced by different combinations of acrocentrics.

If the contribution of Robertsonian translocations in chromosomal evolution of *Acomys* species seems indisputable, nothing is known about neither the eventuality of other types of autosomal rearrangements which led to the N. F. variation, nor about the evolution of sex chromosomes, nor about the direction of chromosome evolution. Up to now, only *Acomys airensis* was studied with the use of chromosome banding techniques (Viegas-Péquignot et al. 1983).

Herein we present the data on chromosome banding analysis of a specimen of the *cahirinus-dimidiatus* group, and its comparison with *A. airensis*. We shall provisionally call it *Acomys* cf. *dimidiatus*. There is a double incertitude for doing this. Firstly, *Acomys dimidiatus* (Cretzschmar, 1826) described from Sinai must correspond to the form with $2n = 36$, the karyotype of which was studied by Wahrman & Goitein (1972). Secondly, *Acomys cahirinus* (Desmarest, 1819) was described from Cairo but to our knowledge its karyotype has remained unknown. Wahrman & Zahavi (1953) published a karyotype with $2n = 38$ from animals called *A. cahirinus*

Table 1: Karyotype data on the species of the genus *Acomys**.

No. Species	2n	NF	X	Y	References
1. <i>A. percivali</i> Dollmann, 1911	36	68	A	A	Matthey, 1968
2. <i>A. cahirinus</i> (Race I)	36	68	A	A	De-Hondt et al., 1977
3. <i>A. minous</i> Bate, 1903, (Race I)	38	66	A	A	Matthey, 1963
4. <i>A. seurati</i> Heim de Balsac, 1937	38	68	A	A	Matthey & Baccar, 1967
5. <i>A. nesiotes</i> Bate, 1903	38	68	A	A	Zahavi & Wahrman, 1956
6. <i>A. cahirinus</i> Desmarest, 1819 (Race II)	38	72	A	A	Wahrman & Zahavi, 1953; Matthey, 1954, 1963
7. <i>A. dimidiatus</i> (= <i>cahirinus</i> ?)	38	70	A	A	Al-Saleh, 1988
8. <i>A. sp.**</i>	38	70	A	A	Present study
9. <i>A. minous</i> Bate, 1903 (Race II)	40	68	A	A	Matthey, 1963
10. <i>A. chudeaui</i> Kollman, 1911	40	69	SM	A	Benazzou, 1983
11. <i>A. airensis</i> Thomas & Hinton, 1921**	42	68	A	A	Tranier, 1975; Viegas-Péquignot et al., 1983
12. <i>A. ignitus</i> Dollman, 1910	50	66-70	A?	SM?	Matthey, 1956
13. <i>A. spinosissimus</i> Peters, 1852	60	72	SM	SM	Dippenaar & Rautenbach, 1986
14. <i>A. selousi</i> De Winton, 1897	60	70-72	M	A	Matthey, 1965a
	58-62	68-75	M	A	
15. <i>A. wilsoni</i> Thomas, 1892	60	76	A?		Matthey, 1968
16. <i>A. subspinosus</i> Waterhouse, 1838	64	72	M	A	Matthey, 1965b; Dippenaar & Rautenbach, 1986
	64	74	M	SM	
17. <i>A. russatus</i> Wagner, 1840	66	>66; >68	?	?	Wahrman & Zahavi, 1953

* From Dippenaar & Rautenbach (1986) modified and expanded.

** Chromosome banding data present.

because of morphological resemblance between specimens from Israel and those from Egypt and by their geographical proximity. These authors estimated that *A. dimidiatus* is a subspecies of *A. cahirinus*. Like Ellerman (1941), they noted the impossibility to rely on morphology for differentiation of the forms of the *cahirinus-dimidiatus* group. Besides, Thomas (1923) described another species belonging to the group, *A. homericus* from Aden.

Material and methods

The specimen studied, a female, came from the vicinity of Taif, Saudi Arabia, from a rocky place at an altitude of 1500 m. The chromosome analysis was performed on preparations obtained from fibroblast culture established after tail biopsy. Explants and a portion of the cells of studied specimens are routinely kept in liquid nitrogen in the cell and tissue collection of the Structure et Mutagenèse Chromosomiques Laboratory. Mitotic chromosomes have been studied with RGH R-banding and CBG C-banding (see ISCN 1985) after, respectively, Carpentier et al. (1972) and Sumner (1972). The replication banding (RBG) has been studied following the method of Viegas-Péquignot & Dutrillaux (1978). At least 10 metaphase and 10 prometaphase plates have been analysed.

Results and discussion

The specimen of our study came from a locality which is between those of *A. cahirinus* and *A. dimidiatus*, and *A. homericus*. The specimens from the Near East which are in our possession all are very close one to another and are extremely polymorph in their fur, skulls and teeth (Figs 1 & 2). The skull comparison is poorly

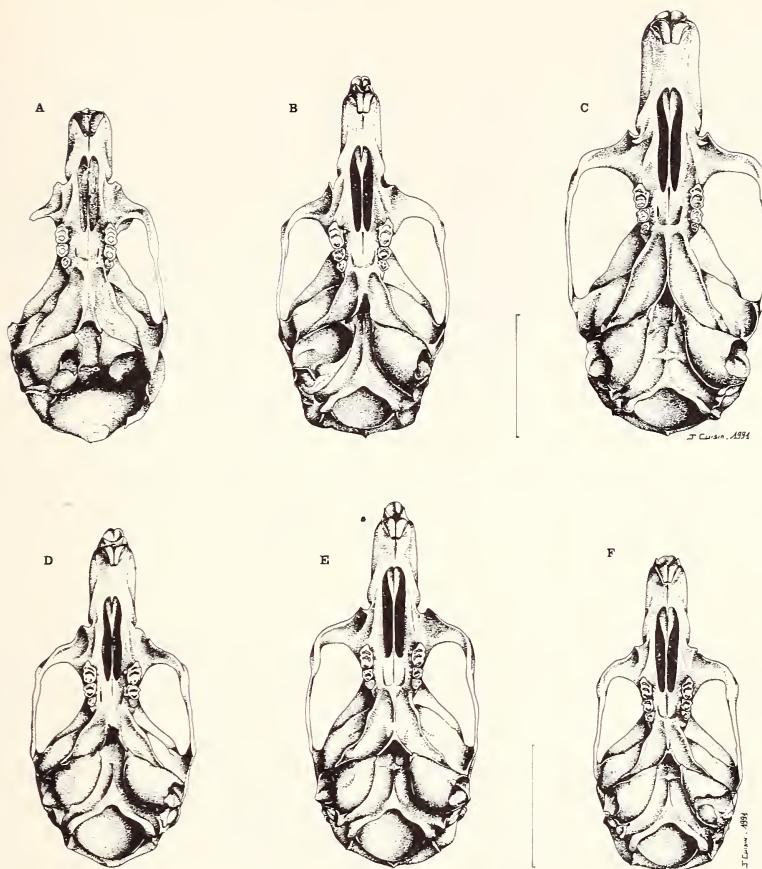


Fig. 1: Skulls of *Acomys*, scale 10 mm. UP: A. *A. cahirinus* paratype; B. *A. cf. dimidiatus* Israel; C. *A. cf. dimidiatus* Israel breed; DOWN: D. *A. cf. dimidiatus* Taif, Arabia; E. *A. airensis* Agadès, Niger; F. *A. airensis* Agadès breed.

informative (Fig. 1) and the teeth comparison is also very difficult although in this case the differences between *A. cf. dimidiatus*, *A. cahirinus* and *A. airensis* are more significant.

The six specimens chosen to illustrate this discussion are far from representing the variability of each geographic form. All measurements widely overlap and morphological traits look inconstant; all these imprecisions are characteristic of the genus *Acomys*.

The paratype of *Acomys cahirinus* is different from specimens of *Acomys cf. cahirinus* from Israel. In particular, outline of tubercle T7 on M2 of paratype is well noticeable but may be the result of individual variation. The form from the north of Israel characterized by $2n = 38$ and represented here by 2 individuals with extreme skull dimensions is larger than the *A. cahirinus* paratype and moreover the molars

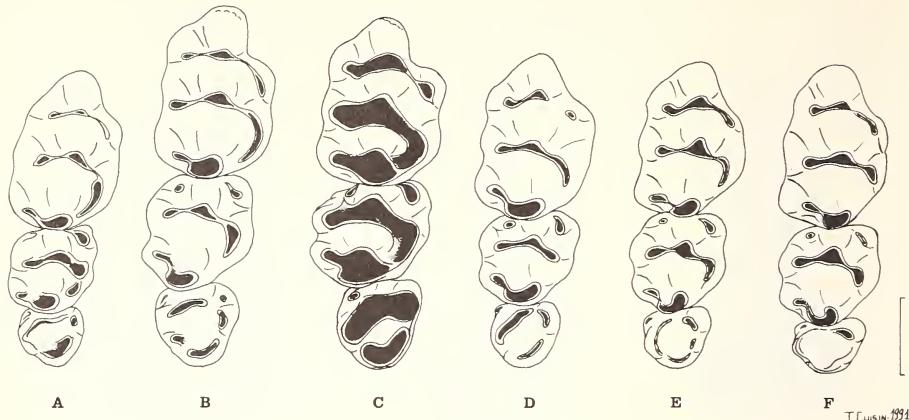


Fig. 2: Right upper molar row (M1) of *Acomys*, scale 10 mm. A. *A. cahirinus* paratype; B. *A. cf. dimidiatus* Israel; C. *A. cf. dimidiatus* Israel breed; D. *A. cf. dimidiatus* Taif, Arabia; E. *A. airensis* Agadès, Niger; F. *A. airensis* Agadès breed.

are clearly different (dimensions and prelobe, Fig. 2). *Acomys* from Taif whose karyotype is presented here draws nearer to the form from Israel. Finally, *A. airensis* is very different from Asian *Acomys* studied and presented here: the molars are small and narrow, and the outline of the prelobe is less angled (Fig. 2).

The karyotype of *Acomys cf. dimidiatus* comprises 38 chromosomes with 16 pairs of meta- and submetacentric, 2 pairs of acrocentric and two acrocentric X chromosomes (Fig. 3). The N. F. is equal to 70. C-banding exhibits small blocks of heterochromatin on about half of chromosomes, including X chromosomes, which display heteromorphism (Fig. 4).

Among the species of the genus *Acomys* karyologically studied previously, only one specimen of *Acomys airensis* was studied with banding techniques (Viegas-Péquignot et al. 1983). This species had a diploid number $2n = 42$ and N. F. = 68. Comparative analysis of the banding pattern in these two species reveals homology between all but three chromosome arms or acrocentric chromosomes (Table 2). As can be reconstructed from Table 2 data, all acrocentric chromosomes in the 2 species were fused in different combinations so that there are no identical biarmed chromosomes in their karyotypes. Thus, the difference of the karyotypes is due not only to different numbers of Robertsonian translocations but above all to different combinations of fusions. It was mentioned above that 3 chromosome arms in *A. cf. dimidiatus*, namely 11q, 14p and 15q, have no homologous chromosomes in *A. airensis*. The nature of the rearrangements differentiating these chromosomes could not be identified. It is very likely that a centromere shift followed by a Robertsonian translocation has occurred in the chromosome evolution of the lineage leading to *A. airensis*. This would explain the difference between chromosomes 16 in *A. cf. dimidiatus*, biarmed, and 7 in *A. airensis*, acrocentric. Indeed this results in a change of the N. F.

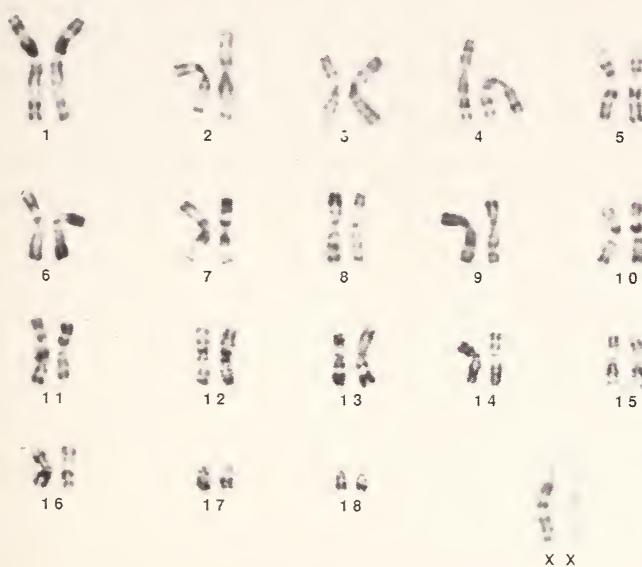


Fig. 3: R-banded karyotype (RBG) of *A. cf. dimidiatus*. The X chromosome on the right is replicating late.

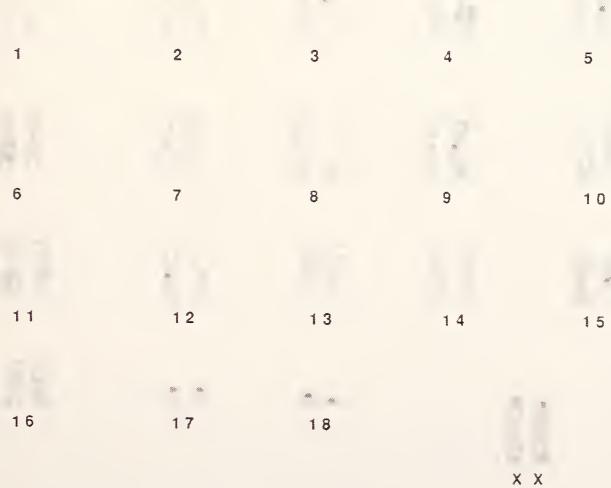


Fig. 4: C-banded karyotype of *A. cf. dimidiatus*.

The comparative analysis undoubtedly indicates a common origin of the 2 species from an ancestor characterized by a karyotype composed of acrocentrics only, with the possible exception of the chromosome corresponding to No. 16 in *A. cf. dimidiatus* which might be either acrocentric or metacentric. This ancestral population was separated and gave rise to at least two lineages (African and Arabian) with independent subsequent Robertsonian evolutions.

Living exclusively among rocks, *Acomys* has a patchy distribution, with many populations isolated on cliffs and rocky hills. *Acomys* being neither a good runner,

Table 2: Corresponding chromosomes and chromosome arms of *Acomys* sp. and *A. airensis*.

<i>Acomys</i> sp. Taif (2n = 38, NF = 70)		<i>Acomys</i> <i>airensis</i> * (2n = 42, NF = 68)
1p	.....	6q
1q	.....	1q
2p	.....	5p
2q	.....	2p
3p	.....	7p
3q	.....	15
4p	.....	10p
4q	.....	2q
5p	.....	16
5q	.....	14
6p	.....	12q
6q	.....	10q
7p	.....	8q
7q	.....	3q
8p	.....	11q
8q	.....	3p
9p	.....	11p
9q	.....	9q
10p	.....	4p
10q	.....	9p
11p	.....	12p
11q	.....	?
12p	.....	18
12q	.....	8p
13p	.....	6p
13q	.....	13q
14p	.....	?
14q	.....	17
15p	.....	13p
15q	.....	?
16pq	.....	7q**
17	.....	19
18	.....	20
X	.....	X
Y	.....	?

* Data from Viegas-Péquignot et al., 1983.

** Centromeric shift followed by Robertsonian translocation (see text for explanation).

nor a climber, nor a digger, its possibilities of colonization are slow and restricted. In *Acomys* there is a strong founding effect, which leads to a great micropopulational variation (Nevo 1985).

Taking into account the peculiarities of *Acomys* population biology and its large geographical distribution (South West Asia and almost all Africa) on one side, the early (from karyotypic point of view) separation of Arabian and African lineages on the other side, it is likely that there are multiple chromosomal races or/and sibling species over *Acomys* distributional range, which would be karyotypically intermediate between *A. cf. dimidiatus* and *A. airenensis*. Their detection may exclusively be done by chromosome banding analysis.

Other examples of the formation of chromosome races by involvement in Robertsonian translocations of different acrocentrics from a same initial chromosome pool are well known. For example, in the house mice, *Mus musculus*, about 50 different karyotypic forms were described with the limits of interpopulational variation of chromosome numbers from 22 to 40 (for reference see Winking et al. 1988). In the common shrew, *Sorex araneus*, no less than 20 chromosome races were detected using chromosome banding analysis (for references see Searle 1988). In both cases no morphological differences were noticed between chromosomal races. The same is true for the sibling species *S. araneus* and *S. coronatus*, which are distinguishable by subtle morphological characters and a few biochemical characters (Neet & Hausser 1989). The difficulty to find morphological distinctions among *Acomys* species, especially in the *cahirinus-dimidiatus* group, was noted by Ellerman (1941) who nevertheless listed 38 species in the genus. The more recent revisions of the genus propose the existence of 7 (Honacki et al. 1982), 9 (Corbet & Hill 1987), or at least 10 species (Petter 1983). These uncertainties in the evaluation of the composition of the genus *Acomys* might be resolved at least partially by chromosome banding analyses.

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Vitaly T. Volobouev and Bernard Dutrillaux, Structure et Mutagénèse Chromosomiques, Institut Curie, Section de Biologie, 26, rue d'Ulm, 75231 Paris Cedex 05, France; Michel Tranier, Muséum National d'Histoire Naturelle, 55, rue Buffon, 75005 Paris, France. Request reprints from: Dr. Vitaly Volobouev.

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